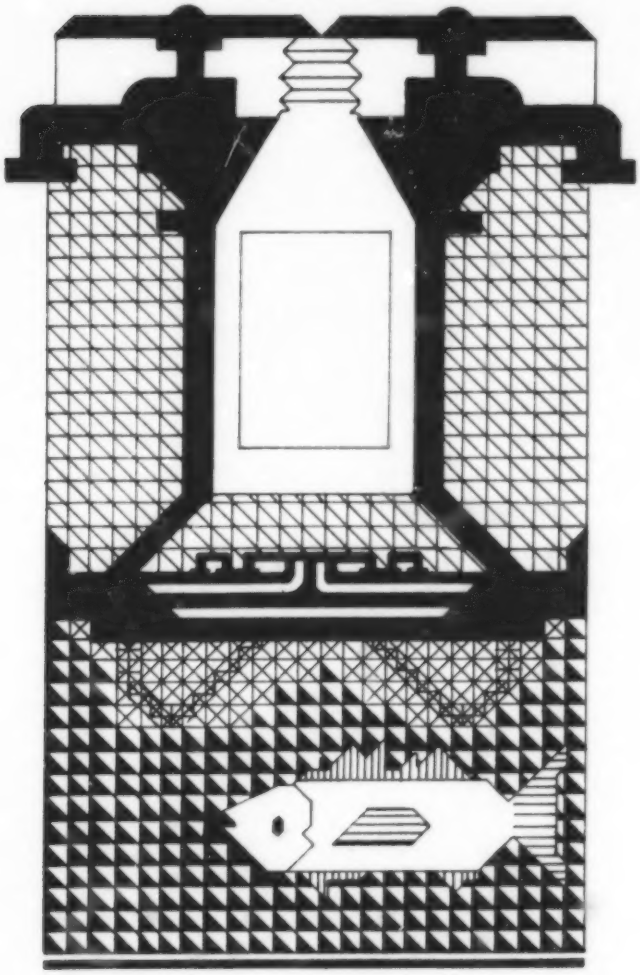
THE QUALITY OF **DRINKING WATER** IN TORONTO



A REVIEW OF:
Tap Water, Bottled Water
And Water Treated
By A Point-Of-Use Device

Summary Report
September, 1990

City of Toronto
Department of Public Health

City of Toronto
Department of Public Health
Environmental Protection Office

SUMMARY REPORT

THE QUALITY OF DRINKING WATER IN TORONTO: A REVIEW OF TAP WATER, BOTTLED WATER AND WATER TREATED BY A POINT-OF-USE DEVICE

P.R.W. Kendall, MBBS, MSc, FRCPC
Medical Officer of Health

September 1990

90-07047/

TABLE OF CONTENTS

NOTICE 1

EXECUTIVE SUMMARY 2

1.0 INTRODUCTION 3

Public Concern 3
Scientific Basis for Concern 3
The Healthy City Initiative 4
Goals and Objectives 4

2.0 PERCEPTION AND USE OF DRINKING WATER ALTERNATIVES IN TORONTO 5

3.0 DRINKING WATER ALTERNATIVES AVAILABLE 5

4.0 REGULATION OF DRINKING WATER 6

5.0 SAMPLING METHODS 6

6.0 CHEMICAL AND BACTERIOLOGICAL QUALITY OF TAP WATER 7

Trace Organic Contaminants 7
Trace Metals 13
Bacteria 14

7.0 CHEMICAL AND BACTERIOLOGICAL QUALITY OF BOTTLED WATER ... 14

Trace Organic Contaminants 14
Trace Metals 14
Bacteria 20

8.0 CHEMICAL AND BACTERIOLOGICAL QUALITY OF DEVICE TREATED WATER 20

Trace Organic Contaminants 20
Trace Metals 20
Bacteria 28

9.0 COMPARISON OF TAP WATER, BOTTLED WATER AND DEVICE-TREATED WATER 31

The "Priority" Chemicals 31
Bacteria 32
Potential Health Effects 32

10.0 CANDIDATE TECHNOLOGIES FOR IMPROVING THE QUALITY OF TORONTO TAP WATER 33

Biological Activated Carbon (BAC) 34

Aluminum Reduction Through Process Change 34
Reduction of Lead Through Corrosion Control and Tap Flushing 35
Ozonation to Reduce Trihalomethane Levels 35
Measures the Consumer Can Take at the Point of Consumption 35
Metro Works Department Initiatives to Improve Municipally Treated Drinking Water Quality 36

11.0 REDUCING EXPOSURE RISKS FOR ALTERNATIVE SOURCES OF DRINKING WATER 37

Bottled Water 37
Home Treatment Devices 37

12.0 SUMMARY AND CONCLUSIONS 38

13.0 RECOMMENDATIONS 40

LIST OF TABLES

Table 1 Concentration of Chemicals Detected in Toronto Tap Water Before and After Treatment by an Activated Carbon and a Reverse Osmosis Point-of-Use Device 8

Table 2 Concentration of Chemicals Detected in Seven Major Brands of Bottled Spring Water Delivered to Toronto Homes 15

Table 3 Results of Bacteriological Analysis of Bottled Water 21

Table 4 Removal of Trihalomethanes, TDS, TOC, Aluminum, Lead and Silver by Point-of-Use Devices 24

Table 5 Bacteriological Results for Home Water Treatment Systems 29

NOTICE

No part of this report may be reproduced without the written permission of the Medical Officer of Health for the Department of Public Health, City of Toronto, 7th Floor, East Tower, City Hall.

Persons who witness violation of copyright protection are encouraged to inform the Environmental Protection Office, Department of Public Health (416-392-6788), particularly in cases where excerpted materials are used by retailers to promote or discredit bottled water, point-of-use devices or tap water.

EXECUTIVE SUMMARY

The Department of Public Health initiated this study on drinking water quality in Toronto as the first stage of a larger research effort to identify and assess routes by which chemicals enter the body through water, air, food and soil. Water was chosen as the first area of investigation because of high public concern regarding sources of drinking water, as well as increasing scientific concern about the effects of consuming small quantities of toxic contaminants over a lifetime. Increasingly sophisticated analytical techniques have also shown a multitude of trace chemicals present in the Niagara River and Lake Ontario, the source of Toronto's tap water.

The scope of this study did not permit comparable levels of chemical analysis for both bottled water and tap water. However, the results make an important contribution to the available information on drinking water alternatives. Five separate sampling programs were developed to assess tap water, bottled water and water treated by a point-of-use device. The programs were designed to produce a limited but intensive look at the chemical and bacterial quality of these three sources of Toronto drinking water.

The results of this study indicate the presence of many organic and inorganic trace contaminants in municipally treated drinking water, bottled water, and water treated with a point-of-use device. However, only a few of these compounds present questions as to their health significance. Bacteriological contamination was also noted frequently in device-treated water and bottled water.

The most important conclusion of the study is that tap water is currently the best choice for drinking water in terms of its overall quality. The Department of Public Health does not promote the use of alternatives because of their inconsistent bacteriological quality, their variable chemical quality and the lack of applicable standards to guarantee the quality of the product that reaches the consumer.

The report contains a number of recommendations, including changes to the water treatment process that will remove some of the contaminants assessed to be of most concern. As well, it recommends that the Canadian and Ontario Ministers of Environment seek to virtually eliminate persistent toxic substances in Lake Ontario as a first line of defense. The report also recommends a number of regulatory and enforcement initiatives that will improve the quality of tap water as well as bottled water and water treated by point-of-use devices.

1.0 INTRODUCTION

This study was initiated by the Department of Public Health for three main reasons: high public concern about the quality of drinking water; increasing scientific concern about the effects of life-long consumption of small quantities of toxic contaminants; and the availability of increasingly sophisticated analytical and risk assessment techniques.

Public Concern

In 1981 Toronto's Board of Health asked the Department of Public Health to report on the health effects of contaminants in Toronto drinking water, the possible need for upgrading of water treatment in the city, and the extent to which Toronto's sewer system was contaminating Lake Ontario.

The resulting document released in 1984 and entitled "Toronto's Drinking Water - A Chemical Assessment", found that there was no clear evidence to indicate that the consumption of municipally supplied water had resulted in any observable adverse health effects. In the years since, as increasing numbers of chemicals in the Niagara River and Lake Ontario have been discovered by scientists, public concern has grown considerably. Sales figures for bottled water and point-of-use treatment devices have increased dramatically and recent surveys reveal that more than 25 percent of Torontonians are using an alternative to tap water.

Scientific Basis for Concern

Althougn the quality of Toronto's drinking water is similar to or better than that of drinking water in other municipalities across the province, little is known about the possible long-term health risks associated with long-term and low-level exposures to the many different chemicals found in tap water to date. In particular, concern has been expressed about the levels of trihalomethanes (THMs), compounds produced by the reaction of chlorine (added to disinfect the water) with organic material not removed by the treatment process. The scientific literature also contains reports on the potential health risks associated with on-going exposure to other trace contaminants that occur in Toronto drinking water, such as aluminum and lead, or to mixtures of chemicals.

At present, the ability of scientists to measure trace amounts of chemicals in the environment surpasses their ability to determine the precise health effects of chronic exposures to these chemicals. Very little is known about the ways that chemicals interact in the human body.

Many of these concerns, and others, apply also to bottled water and point-of-use devices. Routine testing for water quality, such as is carried out regularly on tap water by the municipality, is not feasible with point-of-use devices. In the case of bottled water, only limited regulations and standards are in place, creating further uncertainty with respect to quality control.

The City of Toronto Department of Public Health believes that it is necessary to acquire more and better information about the long-term health risks of drinking water. This study is an important step forward towards meeting that goal. As well, it is part of a larger research effort undertaken by the Department to identify and assess all routes of exposure to chemicals, including water, air, food and soil.

The Healthy City Initiative

The project described in this report supports and promotes the Healthy City Initiative outlined in "Healthy Toronto 2000", the Department of Public Health's blueprint document for protecting the public's health in the 1990's. Among the health goals for Toronto defined as part of that initiative, two are particularly relevant to this project:

1. To reduce inequities in health opportunities in Toronto; and

2. To create physical environments supportive of health.

Within the Public Health Department, applied research on issues dealing with environmental threats to health is now primarily the responsibility of the Environmental Protection Office, which conducted the work described in this report.

Goals and Objectives

The primary goal of this study was to assess the quality of drinking water available to Torontonians, and to make recommendations for improvement, if necessary.

Specific objectives included:

1. To review the current data available on the sources of drinking water in Toronto, both tap water and alternatives, and to review the regulatory framework controlling drinking water quality;

2. To assess public perception and use of tap water and its alternatives such as bottled water and water treated in the home;

3. To measure and assess the actual levels of chemical and bacteriological contamination of drinking water in municipally treated water and alternative sources;

4. To evaluate the exposures and risks associated with chemicals and bacteria in drinking water from all major sources;

5. To review the various control options for reducing chemical and bacteriological exposures associated with the major sources of drinking water;

6. To recommend measures for the improvement of drinking water quality as warranted;

7. To provide a detailed report that will serve as a source of information both for other government agencies and for the general public.

The major findings of the study are summarized in the following pages. More detailed information can be obtained by referring to the full report and its technical appendices.

2.0 PERCEPTION AND USE OF DRINKING WATER ALTERNATIVES IN TORONTO

A telephone survey of 200 randomly-chosen households in the City of Toronto revealed a high level of concern about chemical pollutants in tap water. More than half the households surveyed felt there were "some" or "a lot" of chemicals in the water. About the same percentage said they would be willing to pay a higher water bill to help remove chemical pollutants, with the acceptable increase typically being $25 annually. This willingness to pay occurred not only in high-income households, but in lower income households where the level of concern was high.

The telephone survey showed that 20 percent of the people interviewed used bottled water instead of tap water on a regular basis, 11 percent used home water treatment devices, and ten percent boiled their tap water to treat it. This is consistent with other recent studies that show 22 to 30 percent of Toronto residents are currently using alternatives to tap water on a regular basis. In the last five years alone, the use of alternatives to Toronto tap water has quadrupled.

3.0 DRINKING WATER ALTERNATIVES AVAILABLE

More than 35 brands of home water treatment devices are available on the Toronto market. The most commonly used device in Toronto is the activated carbon filter, but reverse osmosis devices and

distillation units are also used, as are combination units (for instance, activated carbon plus reverse osmosis).

More than 70 different bottled water products (66 brands) are currently available on the Toronto market. Many of these come from outside Ontario. Products include spring and treated water intended for use as an alternative to tap water, which amount to 50 percent of the brands, and mineral waters.

4.0 REGULATION OF DRINKING WATER

Canada has no legally enforceable standards for drinking water, except in Quebec where a limited number of standards apply to bottled water. This is in marked contrast to the United States (U.S.), where the Safe Drinking Water Act sets out regulatory limits which, if contravened, can lead to prosecution of the offender by a government agency or a private citizen. Many toxic organic compounds of concern do not have guidelines available. Eventually, the U.S. Safe Drinking Water Act will regulate 83 contaminants.

In Canada, the number of contaminants with guidelines that are not legally enforceable, is much smaller. The bacteriological and chemical quality of municipal tap water is regulated under the Canadian Drinking Water Guidelines (CDWG) and the Ontario Drinking Water Objectives (ODWO). In contrast, bottled water is considered a food and is regulated primarily for bacteria under the Food and Drugs Act. Neither the chemical nor the bacteriological quality of water generated by home water treatment devices is regulated under federal or provincial guidelines. Instead, water treatment devices are regulated under the Competition Act and the Consumer Packaging and Labelling Act by the federal Department of Consumer and Corporate Affairs to control false or misleading advertising.

5.0 SAMPLING METHODS

Five separate sampling programs were developed to assess tap water, bottled water and device-treated water. Except where indicated, standard methods were employed for all analyses:

* High-volume, low-detection-limit analysis of pollutants in Toronto tap water (triplicate analyses) using 300-400 litre samples concentrated through XAD resin-packed "flow-through" sampling devices;

* Controlled-condition assessment of the chemical removal efficiency of two point-of-use devices in reducing chemicals that occur in Toronto tap water. The two treatment technologies tested were activated carbon and reverse osmosis (duplicate analyses). Three to four hundred litre

samples were concentrated through XAD resin-packed "flow-through" sampling devices;

* Field testing of point-of-use devices in use in 25 Toronto homes included chemical and bacteriological analysis for each home consisting of 100 millilitre (ml) samples of tap water with and without additional treatment;

* Chemical analysis of seven popular brands of bottled water delivered to Toronto homes with testing carried out once on 40 litre samples;

* Bacteriological assessment of 66 types of bottled water available in Toronto including triplicate analyses.

6.0 CHEMICAL AND BACTERIOLOGICAL QUALITY OF TAP WATER

Toronto tap water meets existing Canadian and Ontario drinking water guidelines. However, of the 66 substances measured in Toronto tap water, only 17 have guideline values. Only some of these values are based on health considerations.

Table 1 provides a summary of the quality of Toronto tap water as assessed through the low detection limit study under controlled conditions in the Environmental Protection Office. It also contains data on concentrations after treatment by an activated carbon device and a reverse osmosis device.

Trace Organic Contaminants

In all, 66 substances were measured in Toronto tap water during at least one of the three sampling periods. Eight of these substances (calcium, iron, magnesium, manganese, potassium, phosphorus, sodium and zinc) are considered nutrients at the levels found, and are required by the body in small amounts. The other 58 substances are classified as contaminants in this report because at high doses they are injurious to health and are not considered essential to bodily functioning. Of these 58 contaminants, 42 were found in at least two of the three samples analyzed, and may therefore occur with regularity in Toronto tap water.

Water leaving Toronto's three water treatment plants has among the lowest trihalomethane (THM) levels when compared with other Ontario communities. THM levels in Toronto averaged 20 to 25 ppb (1) during 1986 and 1987. In contrast, some other communities

(1) ppb means parts per billion, a measurement of concentration equivalent to micrograms per litre of water.

Table 1 Concentration of Chemicals Detected in Toronto Tap Water Before and After Treatment by an Activated Carbon and a Reverse Osmosis Point-of-Use Device. (a)

Parameter	Preliminary Trial	Trial 1			Trial 2			Detection Limit
UNITS: ng/L	Tap Water	Tap Water	After Activated Carbon	After Reverse Osmosis	Tap Water	After Activated Carbon	After Reverse Osmosis	
CHLORINATED COMPOUNDS								
1,3-Dichlorobenzene	0.5	1.7	0.13		1.6	0.08		0.03
1,4-Dichlorobenzene	1.6	5.8	1.4	1.06	2.6	0.49	0.43	0.07
1,2-Dichlorobenzene	0.2	1.1	0.22	0.15	1.1	0.15	0.10	0.03
1,3,5-Trichlorobenzene	0.02	0.06			0.05			0.003
1,2,4-Trichlorobenzene	0.1	0.49	0.12	0.11	0.68	0.20	0.08	0.003
1,2,3-Trichlorobenzene	0.04	0.13	0.04	0.02	0.15	0.05	0.02	0.003
1,2,3,5 + 1,2,4,5-Tetrachlorobenzene	0.03							0.003
1,2,3,4-Tetrachlorobenzene	0.02	0.10	0.03	0.03	0.13	0.04	0.03	0.003
Pentachlorobenzene	0.02	0.04	0.01	0.01	0.06	0.02	0.02	0.001
Hexachlorobenzene	0.03	0.06			0.07			0.0007
Hexachloroethane	1.2							0.0007
Hexachlorobutadiene	0.005							0.0007
Alpha-Hexachlorocyclohexane		2.4		0.18	2.3		0.15	0.002
Lindane*		0.3			0.3			0.002
Heptachlor								0.003
Heptachlor Epoxide								0.003
Octachlorostyrene								0.0007
Gamma-Chlordane								0.001
p,p'-DDE	0.02							0.002
p,p'-DDD								0.007
p,p'-DDT								0.01
Mirex								0.003
Methoxychlor								0.003
Total PCBs								0.003

NOTE: Blank spaces indicate that the sample is below detection limit.
(a) Data expressed as nanograms per litre.
* Methodology used in preliminary trial was not suitable for the detection of lindane in this sample.

Table 1 Concentration of Chemicals Detected in Toronto Tap Water Before and After Treatment by an Activated Carbon and a Reverse Osmosis Point-of-Use Device. (a) (continued)

Parameter	Preliminary Trial	Trial 1			Trial 2			Detection Limit
UNITS: ng/L	Tap Water	Tap Water	After Activated Carbon	After Reverse Osmosis	Tap Water	After Activated Carbon	After Reverse Osmosis	
ACID EXTRACTABLES								
2,3,4,5-Tetrachlorophenol								0.2
2,3,4,6-Tetrachlorophenol								0.2
2,3,5,6-Tetrachlorophenol								0.2
2,3,4-Trichlorophenol								0.2
2,3,5-Trichlorophenol								0.2
2,4,5-Trichlorophenol								0.2
2,4,6-Trichlorophenol								0.2
2,4-Dimethylphenol								0.08
2,4-Dichlorophenol								0.07
2,6-Dichlorophenol								0.07
4,6-Dinitro-o-cresol								0.7
2-Chlorophenol								0.2
4-Chloro-3-methylphenol								0.09
4-Nitrophenol								0.2
m-Cresol								0.1
o-Cresol								0.1
p-Cresol								0.1
Pentachlorophenol	0.3							0.1
Phenol								0.04
Dibromophenol	0.23							0.1
Bromochlorophenol	0.26							0.1
2,4,6-Tribromophenol	0.51	NS	NS	NS	NS	NS	NS	0.1
2,4-Dichlorophenoxyacetic acid (2,4-D)								2
4-(2,4-Dichlorophenoxy)-butyric acid (2,4-DB)								0.3
2,4,5-Trichlorophenoxy acid (2,4,5-T)								2
2-(2,4,5-Trichlorophenoxy)-propionic acid (Silvex)								0.9

NOTE: Blank spaces indicate that the sample is below detection limit.
(a) Data expressed as nanograms per litre.
NS Not Sampled

Table 1 Concentration of Chemicals Detected in Toronto Tap Water Before and After Treatment by an Activated Carbon and a Reverse Osmosis Point-of-Use Device. (a) (continued)

Parameter	Preliminary Trial	Trial 1			Trial 2			
UNITS: ng/L	Tap Water	Tap Water	After Activated Carbon	After Reverse Osmosis	Tap Water	After Activated Carbon	After Reverse Osmosis	Detecti Limit
BASE NEUTRALS								
Acenaphthene	1.7	2.2	0.6	0.34	1.4	0.44		0.02
5-nitro Acenaphthene	NS							1.0
Acenaphthylene	2.1	2.6		0.16	1.9	0.43	0.18	0.01
Anthracene	1.7	1.3	0.13		1.6	0.16	0.14	0.01
Benz(a)anthracene	0.15							0.01
Benzo(a)pyrene								0.01
Benzo(b)fluoranthene and Benzo(k)fluoranthene	0.09							0.01
Benzo(g,h,i)perylene	0.03							0.01
Camphene								0.03
1-Chloronaphthalene								0.01
2-Chloronaphthalene								0.01
Chrysene	0.59							0.01
Dibenz(a,h)anthracene	0.08							0.06
Fluoranthene	6.45	6.5		0.26	7.5	0.15		0.01
Fluorene	3.7	4.76	0.95	0.99	3.7	1.08	1.1	0.01
Indeno(1,2,3-cd)pyrene	0.18							0.01
Indole								0.01
1-Methylnaphthalene								0.02
2-Methylnaphthalene	2.82	4.62	2.59	1.6	2.55	2.0	1.4	0.02
Naphthalene	5.0	16.5	14.7	7.7	8	15.3	4.7	0.01
Perylene	0.15							0.01
Phenanthrene	17.12	21.45	1.96	1.81	18.71	2.36	2.12	0.01
Pyrene	3.84	3.0	0.15	0.22	3.5	0.13		0.01
Benzylbutylphthalate	0.8							0.02
Bis(2-ethylhexyl)phthalate	13.0	1904	754	809	1113	924	1074	0.3
Di-n-butylphthalate	13.81	182.4	338.4	392.9	74.9	250.4	340.4	0.3
4-Bromophenyl phenyl ether								0.02
4-Chlorophenyl phenyl ether								0.02
Bis(2-chloroisopropyl)ether								0.02
Bis(2-chloroethyl)ether								0.03
2,4-Dinitrotoluene								0.08
2,6-Dinitrotoluene								0.08
Bis(2-chloroethoxy)methane	NS							1.0
Diphenylamine	2.8	12	5.0	2.31	6.2	3.8	1.5	0.01
N-Nitrosodiphenylamine	NS							1.0
N-Nitrosodi-n-propylamine								0.06
Benzothiozole	1.05	9.2	15.3	6.45	4.75	11.3	3.86	0.01

NOTE: Blank spaces indicate that the sample is below detection limit.
(a) Data expressed as nanograms per litre.
NS Not Sampled.

Table 1 Concentration of Chemicals Detected in Toronto Tap Water Before and After Treatment by an Activated Carbon and a Reverse Osmosis Point-of-Use Device. (b) (continued)

Parameter	Preliminary Trial	Trial 1			Trial 2			Detection Limit
UNITS: ug/L	Tap Water	Tap Water	After Activated Carbon	After Reverse Osmosis	Tap Water	After Activated Carbon	After Reverse Osmosis	
VOLATILE ORGANICS								
1,1,2,2,-Tetrachloroethane								0.1
1,1,2-Trichloroethane								0.03
1,1,1-Trichloroethane								0.03
1,1-Dichloroethane								0.04
1,1-Dichloroethylene								0.04
1,2-Dichloroethane (c)								0.04
1,2-Dichloropropane								0.04
Bromomethane								0.07
Carbon tetrachloride								0.06
Chlorobenzene								0.04
Chloromethane								0.07
Cis-1,3-Dichloropropylene								0.05
Ethylene dibromide								0.04
Methylene chloride								0.1
Tetrachloroethylene (d)	0.02	0.05			0.07			0.03
Trans-1,2-Dichloroethylene								0.05
Trans-1,3-Dichloropropylene								0.06
Trichloroethylene	0.08	0.12	0.01		0.08			0.01
Trichlorofluoromethane								0.1
Vinyl chloride (e)								0.1
Chloroform	5.45	4.95			3.8			0.05
Bromodichloromethane	5.0	4.4			5.3			0.04
Dibromochloromethane	2.05	2.22			1.65			0.04
Bromoform		0.08						0.02
Total Trihalomethanes	12.5	11.65			10.75			0.04
Benzene								0.06
Ethylbenzene								1.0
Styrene								0.08
Toluene	0.06	0.11	0.08	0.05	0.05	0.05		0.05
o-Xylene	0.02	0.03						0.03
m-Xylene and p-Xylene	0.06	0.04	0.02		0.02			0.02

NOTE: Blank spaces indicate that the sample is below detection limit.
(b) Data expressed in micrograms per litre.
(c) Also known as ethylene dichloride.
(d) Also known as perchloroethylene.
(e) Also known as chloroethylene.

Table 1 Concentration of Chemicals Detected in Toronto Tap Water Before and After Treatment by an Activated Carbon and a Reverse Osmosis Point-of-Use Device. (continued)

Parameter	Preliminary Trial	Trial 1			Trial 2			Detection Limit
UNITS: As indicated for individual parameters	Tap Water	Tap Water	After Activated Carbon	After Reverse Osmosis	Tap Water	After Activated Carbon	After Reverse Osmosis	
METALS AND OTHER PARAMETERS								
Aluminum (ug/L)	70	70	35	5	45	25	5	5.0
Arsenic (ug/L)								1.0
Barium (ug/L)	20	20	20	10	20	20		10
Beryllium (mg/L)								0.01
Cadmium (ug/L)								0.1
Calcium (mg/L)	38	40	40	1.15	40	40	22.5	0.01
Chromium (ug/L)	1				1			1.0
Cobalt (ug/L)								0.01
Copper (ug/L)	31	27	47	27	59	113	28	2.0
Iron (ug/L)	40	40			40			20
Lead (ug/L)	2		2	1	2	7	1	1.0
Magnesium (mg/L)	7.8	7.6	7.7	0.15	7.8	7.6	0.1	0.01
Manganese (ug/L)	2	2	2	1	3	3		1.0
Mercury (ug/L)								0.05
Molybdenum (ug/L)								20
Nickel (ug/L)					80	40		10
Potassium (mg/L)	1.65	1.55	1.65	0.10	1.70	1.60	0.075	0.05
Selenium (ug/L)								1.0
Silver (ug/L)								0.1
Sodium (mg/L)	12.0	11.5	12.0	1.0	12.0	11.5	0.5	0.01
Strontium (mg/L)	0.18	0.18	0.18	0.02	0.18	0.18		0.01
Total Cyanide (mg/L)	0.003				0.01	0.008	0.003	0.002
Total Organic Carbon (mg/L)	2.5	1.5			1.5			0.5
Total Phosphorus (mg/L)	0.003							0.001
Vanadium (ug/L)								10
Zinc (mg/L)	0.02		0.04	0.27	0.06	0.11	0.08	0.01

NOTE: Blank spaces indicate that the sample is below detection limit.
Units for data shown in brackets after parameter name.

in Ontario have THM levels that, while meeting current Canadian guidelines of 350 ppb (under review), exceed the U.S. standard of 100 ppb. The United States is currently considering dropping its existing guideline of 100 ppb to 30 ppb. The trihalomethanes include chemicals like chloroform that are known animal carcinogens and suspected human carcinogens.

Trace Metals

Trace metals in tap water were generally below Ontario Drinking Water Guidelines. However, two exceptions deserve special note because of concerns regarding their potential impact on human health:

(a) Lead

Lead levels in treated water leaving Toronto's water treatment plants are typically less than 1 ppb. Lead can leach from lead pipes and lead solder joints in the water distribution system, particularly if the water is corrosive. In the City of Toronto, about 80 percent of pipes providing water to homes are lead based, and much of the interior plumbing in homes is copper piping with lead solder joints.

The amount of lead leaching into tap water correlates with the length of time water has been standing unused in the plumbing. In the current study, average lead concentrations in the home were 5 ppb if the water was standing unused for less than five hours, 18 ppb if standing 5 to 8 hours and 28 ppb if standing more than 8 hours. The proposed U.S. standard for maximum lead levels in drinking water is 10 ppb based on the collection of 8 to 18 hour standing water samples at the consumer's tap. However, in Canada, the guideline is 50 ppb, based on the assumption of a free-flowing water sample. The Department of Public Health does not believe that this offers sufficient protection against conditions often found in the home. The Department therefore recommends that Toronto residents flush their taps for three to five minutes or until the water runs cold prior to drinking if water has been standing unused in the plumbing for more than five hours. Developmental effects on children and elevated blood pressure in adults have been reported at blood lead levels lower than five micrograms per litre. Lead is classified as an animal carcinogen and a suspected human carcinogen.

(b) Aluminum

Aluminum levels in Toronto drinking water rank in the middle of levels that occur in Ontario communities, and are typically between 100 and 150 ppb. However, the levels fluctuate dramatically throughout the year, ranging from about 50 ppb in the winter to about 325 ppb in the summer. In this study, the average aluminum level in 27 Toronto homes was 191 ppb in October 1989.

At present, no health-based guideline exists in Canada for aluminum, although Ontario has non health-based guideline of 100 ppb. Aluminum at comparable levels to that found in Toronto's drinking water has been linked to Alzheimer's Disease in a limited number of studies.

Bacteria

In most cases, tap water met Ontario guidelines at the tap, even though those guidelines apply at the treatment plant or to a free-flowing sample from the distribution system (see Table 5.0). The occasional presence of bacteria at elevated levels at the consumer's tap poses little or no health risk. However, those bacteria can multiply on carbon filters in the home, and over time create unacceptable bacteriological water quality for the consumer who uses those devices.

7.0 CHEMICAL AND BACTERIOLOGICAL QUALITY OF BOTTLED WATER

Although the Canadian Drinking Water Guidelines apply only to tap water and not to bottled water, most brands of bottled water meet these limited guidelines. A number of exceptions do occur, however, particularly for fluoride and sodium levels in mineral waters. Fluoride and sodium levels are printed directly on the bottle label, so consumers can avoid those brands exceeding the tap water guidelines if they choose.

Trace Organic Contaminants

Chemical analysis was conducted on seven of the most popular brands of bottled water delivered to Toronto homes. Table 2 presents the results of this analysis. None of the brands analyzed had detectable levels of trihalomethanes unlike tap water, which always has measurable levels present. However, all seven brands of spring water had levels of 1,4-dichlorobenzene that were considerably higher than Toronto tap water. In addition, the total concentration of chlorinated compounds (excluding trihalomethanes) was greater than in Toronto tap water.

1,4-dichlorobenzene is a known animal carcinogen and a suspected human carcinogen. The other chlorinated compounds include those (e.g., 1,2,4-trichlorobenzene) known to cause reproductive effects in animals, although the evidence for adverse human effects is inconclusive.

Trace Metals

The seven bottled waters tested had lower levels of aluminum, lead and nickel than Toronto tap water. However, some brands had higher levels of barium, cadmium, cobalt and molybdenum than those found in tap water.

Table 2 Concentration of Chemicals Detected in Seven Major Brands of Bottled Spring Water Delivered to Toronto Homes.

Parameter	Brand of Bottled Spring Water							Blank	Detection Limit
All units: ng/L	Crystal Springs	Caledon Springs	Spring Valley	Ceniti Springs	Highland Springs	Blue Mountain	Cedar Springs		
CHLORINATED COMPOUNDS									
1,3-Dichlorobenzene	3.9	2							1.0
1,4-Dichlorobenzene	66	54	11	190	5.75	18	24	1.0	2.0
1,2-Dichlorobenzene	19	15		5	1.3			2.0	1.0
1,3,5-Trichlorobenzene	0.2		0.22	0.22					0.1
1,2,4-Trichlorobenzene	0.6	0.70		2.9	0.6	0.5	0.3	0.2	0.1
1,2,3-Trichlorobenzene				0.7					0.1
1,2,3,5 + 1,2,4,5-Tetrachlorobenzene								0.3	0.1
1,2,3,4-Tetrachlorobenzene				1.0				0.4	0.1
Pentachlorobenzene								0.2	0.03
Hexachlorobenzene									0.02
Hexachloroethane									0.02
Hexachlorobutadiene									0.02
Alpha-Hexachlorocyclohexane			0.24	0.13					0.05
Lindane									0.05
Heptachlor								0.6	0.1
Heptachlor Epoxide									0.1
Octachlorostyrene									0.02
Gamma-Chlordane									0.04
p,p'-DDE									0.05
p,p'-DDD									0.2
p,p'-DDT									0.3
Mirex									0.1
Methoxychlor									0.1
Total PCBs									0.2

NOTE: A blank space indicates that the concentration of the contaminant was below the detection limit for this sample.

Table 2 Concentration of Chemicals Detected in Seven Major Brands of Bottled Spring Water Delivered to Toronto Homes. (continued)

Parameter All Units: ng/L	Brand of Bottled Spring Water							Blank	Detection Limit
	Crystal Springs	Caledon Springs	Spring Valley	Ceniti Springs	Highland Springs	Blue Mountain	Cedar Springs		
ACID EXTRACTABLES									
2,3,4,5-Tetrachlorophenol									6.0
2,3,4,6-Tetrachlorophenol									6.0
2,3,5,6-Tetrachlorophenol									5.0
2,3,4-Trichlorophenol									7.0
2,3,5-Trichlorophenol									7.0
2,4,5-Trichlorophenol									7.0
2,4,6-Trichlorophenol									6.0
2,4-Dimethylphenol									3.0
2,4-Dinitrophenol									20.0
2,4-Dichlorophenol									2.0
2,6-Dichlorophenol									2.0
4,6-Dinitro-o-cresol									20.0
2-Chlorophenol									2.0
4-Chloro-3-methylphenol									3.0
4-Nitrophenol									7.0
m-Cresol									3.0
o-Cresol									3.0
p-Cresol									3.0
Pentachlorophenol									6.0
Phenol									1.0
2,4-Dichlorophenoxy-acetic acid (2,4-D)									50.0
4-(2,4-Dichlorophenoxy)-butyric acid (2,4-DB)									80.0
2,4,5-Trichloro-phenoxy acid (2,4,5-T)									50.0
2-(2,4,5-Trichlorophenoxy)propionic acid (Silvex)									30.0

NOTE: A blank space indicates that the concentration of the contaminant was below the detection limit for this sample.

Table 2 Concentration of Chemicals Detected in Seven Major Brands of Bottled Spring Water Delivered to Toronto Homes. (continued)

Parameter	Brand of Bottled Spring Water							Blank	Detection Limit
All units: ng/L	Crystal Springs	Caledon Springs	Spring Valley	Ceniti Springs	Highland Springs	Blue Mountain	Cedar Springs		
BASE NEUTRALS									
Acenaphthene				10					5.0
Acenaphthylene									4.0
Anthracene									5.0
Benz(a)anthracene									20.0
Benzo(a)pyrene									50.0
Benzo(b)fluoranthene and Benzo(k)fluoranthene									50.0
Benzo(g,h,i)perylene									50.0
Camphene									2.0
1-Chloronaphthalene									0.4
2-Chloronaphthalene									0.4
Chrysene									10.0
Dibenz(a,h)anthracene									50.0
Fluoranthene									6.0
Fluorene				14					5.0
Indeno(1,2,3-cd)pyrene									40.0
Indole									0.9
1-Methylnaphthalene									0.8
2-Methylnaphthalene		14	6	19	8		6		0.8
Naphthalene		660		550	140	18			3.0
Perylene									2.0
Phenanthrene	26	23		40					6.0
Pyrene									6.0
Benzylbuthyphthalate	44	120	3	54	45		13		1.0
Bis(2-ethylhexyl)-phthalate	150	21	2100	220	160	8	100	17	1.5
Di-n-butylphthalate	48	21	23	49	48	30	55	14	1.5
4-Bromophenyl phenyl ether									3.0
4-Chlorophenyl phenyl ether									2.0
Bis(2-chloroisoproply)-ether									0.6
Bis(2-chloroethyl)ether									1.0
2,4-Dinitrotoluene									10.0
2,6-Dinitrotoluene									20.0
Diphenylamine									10.0
N-Nitrosodiphenylamine									10.0
N-Nitrosodi-n-propylamine									5.0
Benzothiozole	230	210	34	83	210	200	72		0.9

NOTE: A blank space indicates that the concentration of the contaminant was below the detection limit for this sample.

Table 2 Concentration of Chemicals Detected in Seven Major Brands of Bottled Spring Water Delivered to Toronto Homes. (continued)

Parameter	Brand of Bottled Spring Water							Blank	Detection Limit
All units: ug/L	Crystal Springs	Caledon Springs	Spring Valley	Ceniti Springs	Highland Springs	Blue Mountain	Cedar Springs		
VOLATILE ORGANICS									
1,1,2,2,-Tetrachloroethane									0.1
1,1,2-Trichloroethane									0.03
1,1,1-Trichloroethane	0.14		1.5						0.03
1,1-Dichloroethane									0.04
1,1-Dichloroethylene									0.04
1,2-Dichloroethane (Ethylene dichloride)									0.04
1,2-Dichloropropane									0.04
Bromomethane									0.07
Carbon tetrachloride									0.06
Chlorobenzene				0.15					0.04
Chloromethane									0.07
Cis-1,3-Dichloropropylene									0.05
Ethylene dibromide									0.04
Methylene chloride									0.1
Tetrachloroethylene (Perchloroethylene)						0.08			0.03
Trans-1,2-Dichloroethylene									0.05
Trans-1,3-Dichloropropylene									0.06
Trichloroethylene	0.05	0.08			0.05	0.12			0.05
Trichlorofluoromethane									0.1
Vinyl chloride (Chloroethylene)									0.1
Chloroform									0.05
Bromodichloromethane									0.04
Dibromochloromethane									0.04
Bromoform									0.02
Total Trihalomethanes									0.04
Benzene									0.06
Ethylbenzene									0.1
Styrene									0.08
Toluene	0.25	0.25	0.19	0.34	0.07				0.05
o-Xylene									0.1
m-Xylene and p-Xylene		0.07	0.04	0.07	0.02				0.02

NOTE: A blank space indicates that the concentration of the contaminant was below the detection limit for this sample.

Table 2 Concentration of Chemicals Detected in Seven Major Brands of Bottled Spring Water Delivered to Toronto Homes. (continued)

Parameter Units: as indicated below	Brand of Bottled Spring Water							Blank	Detection Limit
	Crystal Springs	Caledon Springs	Spring Valley	Ceniti Springs	Highland Springs	Blue Mountain	Cedar Springs		
METALS AND OTHER PARAMETERS									
Aluminum (ug/L)	5		10	5	5	5	7.5		5.0
Arsenic (ug/L)									1.0
Barium (ug/L)	60	140	20	20	20		110		10.0
Beryllium (mg/L)									0.01
Cadmium (ug/L)							0.1		0.1
Calcium (mg/L)	84	72	91	86	70	54	90		0.01
Chromium (ug/L)			1						1.0
Cobalt (ug/L)	10								10.0
Copper (ug/L)			0.5	1	1				1.0
Iron (ug/L)		20							20.0
Lead (ug/L)									1.0
Magnesium (mg/L)	15.9	17.8	26	11.0	29	25	16.4		0.01
Manganese (ug/L)		2	0.5				2		1.0
Mercury (ug/L)									0.1
Molybdenum (ug/L)			20		20				20.0
Nickel (ug/L)									10.0
Potassium (mg/L)	1.25	1.20	0.95	0.40	0.55	0.60	2.0		0.05
Selenium (ug/L)									1.0
Silver (ug/L)									0.1
Sodium (mg/L)	7.5	4.0	6.5	5.0	4.0	2.0	5.5		0.1
Strontium (mg/L)	0.16	0.18	1.60	0.17	0.10	0.05	0.21		0.01
Total Cyanide (mg/L)					0.004				0.002
Total Organic Carbon (mg/L)	1.5	1.5	1.0	1.75	2.5	1.5	1.5		0.5
Total Phosphorus (mg/L)		0.004		0.004	0.002		0.003		0.001
Vanadium (ug/L)									10.0
Zinc (mg/L)	0.02						0.05		0.01

NOTE: A blank space indicates that the concentration of the contaminant was below the detection limit for this sample.

Bacteria

Testing of 66 different bottled water products available on the Toronto market revealed zero faecal and total coliforms in all brands, thereby meeting Ontario Drinking Water Objectives. In contrast, 29 percent of the bottled water samples exceeded the Ontario guideline of 500 bacteria per millilitre for the aerobic plate count (APC), and 35 percent of samples exceeded the Ontario Bottled Water Association's own guideline of 100 bacteria per millilitre. Twenty-five percent of the brands failed to meet the bottlers' guidelines in all three samples tested. Table 3 gives the results of this assessment.

8.0 CHEMICAL AND BACTERIOLOGICAL QUALITY OF DEVICE-TREATED WATER

Trace Organic Contaminants

New activated carbon and reverse osmosis home water treatment units tested under optimum conditions greatly reduced the level of many contaminants present in Toronto tap water (see Table 1). Table 4 shows removal efficiencies for the devices tested in the field study.

Trihalomethanes were reduced by more than 98 percent, and chlorinated compounds, such as chlorobenzenes, were typically reduced by more than 80 percent with both devices. Many polycyclic aromatic hydrocarbons (PAHs) such as acenaphthylene, anthracene and fluoranthene were lowered more than 90 percent by both units. However, other compounds such as methylnaphthalene were reduced by less than 50 percent. Toluene and xylene were poorly removed by either device.

Trace Metals

The reverse osmosis unit showed a higher removal capacity for metals and other inorganic substances than the activated carbon unit. Sodium, strontium, cyanide and aluminum were removed well by the reverse osmosis unit but not the activated carbon unit. Overall, reverse osmosis units that incorporate activated carbon filters remove a wider range of chemicals than activated carbon units alone.

The results of the field study on the chemical removal efficiency of water treatment devices in use in 25 Toronto homes generally confirmed the results of controlled testing. Where poor removal efficiencies were observed (compared to the controlled test), they were usually the result of poorly maintained or aging devices. These same devices in use in other homes demonstrated good chemical removal efficiencies. In general, activated carbon devices showed a poor ability to remove aluminum. However, the

Table 3 Results of Bacteriological Analysis of Bottled Water (a)

Brand of Bottled Water	Aerobic Plate Count (aerobic bacteria per ml)		
	Sample 1	Sample 2	Sample 3
A & P Carbonated Natural Mineral	<10	<10	10
Apollinaris Mineral	<10	20	<10
Boario Natural Mineral	60	620	40
Boario Carbonated Natural Mineral	<10	<10	<10
Blue Mountain Carbonated Spring	>2000	<10	<10
Blue Mountain Spring	290	395	260
Caledon Springs Spring	630	<10	>2000
Caledon Springs Distilled	<10	<10	<10
Caramulo Still Natural	80	40	120
Castello Carbonated Mineral	<10	80	<10
Cedar Springs	<10	<10	<10
Ceniti Springs	>2000	950	1200
Cool Brook Carbonated Spring	>2000	>2000	>2000
Crodo Carbonated Mineral	<10	<10	<10
Cruzeiro Spring	<10	<10	>2000
Crystal Springs Distilled	<10	<10	<10
Crystal Springs Natural Spring	<10	<10	<10
Dominion Spring	<10	<10	<10
Echo Springs	<10	<10	>2000
Evian Natural Spring	60	770	590
Fern Brook Spring	960	>2000	300
Fern Brook Spring (b)	<10	<10	<10
Ferrarelle Mineral	<10	<10	<10
Fiuggi Natural Spring	<10	<10	40
Fonte S. Moderanno Mineral	<10	<10	<10
Gerolsteiner Sprudel	<10	<10	<10
Health Springs Natural Mineral	30	50	<10
Highland Country Springs	940	720	1700
Iceland Natural Spring (Cynar)	>2000	>2000	>2000
Labrador Spring	<10	<10	>2000
Lombadas Natural Sparkling Mineral	<10	<10	10

(a) Total coliform and faecal coliform counts were 0 for all brands of bottled water.

(b) The second set of results for Fern Brook Natural Spring Water are from samples taken after ozonation was introduced to the company's bottling process, and consequently better represents the current bacteriological quality of their product.

Table 3 Results of Bacteriological Analysis of Bottled Water (a) (continued)

Brand of Bottled Water	Aerobic Plate Count (aerobic bacteria per ml)		
	Sample 1	Sample 2	Sample 3
Lora Carbonated Mineral	<10	<10	<10
Luso Mineral	90	460	1400
Mangiatorella Mineral	<10	<10	<10
Maple Brand	>2000	>2000	>2000
Maqua Spring	>2000	>2000	>2000
Maxima Carbonated Natural Mineral	<10	240	<10
Miracle Food Mart Mineral	<10	<10	<10
Miracle Food Mart Natural Spring	>2000	<10	<10
Miral Radenska Mineral	50	<10	<10
Mont Blanc Carbonated Spring	<10	<10	<10
Montclair Natural Spring	<10	<10	<10
Montprix Dominion Mineral	<10	<10	<10
Naya Natural Spring	1400	890	260
No-Name Mineral	10	<10	<10
Pedras Salgadas Mineral	<10	<10	<10
Perrier Mineral	<10	<10	<10
Polar Distilled	<10	<10	<10
Polar Spring	<10	<10	<10
President's Choice Mineral	<10	<10	<10
President's Choice Natural Spring	>2000	>2000	>2000
Puretap Distilled	>2000	>2000	>2000
Recoaro Mineral	<10	<10	<10
Revos Demineralized	900	1900	1200
Rocky Mountain Carbonated Spring	<10	<10	<10
Roman Springs Spring	>2000	>2000	>2000
Saint Justin Carbonated Mineral	<10	<10	330
Salus Vidago Mineral	<10	<10	<10
Sangemini Natural Mineral	80	<10	<10
Spa Reine Mineral	50	400	<10
Spring Valley Artesian Spring	<10	<10	<10

(a) Total coliform and faecal coliform counts were 0 for all brands of bottled water.

Table 3 Results of Bacteriological Analysis of Bottled Water (a) (continued)

Brand of Bottled Water	Aerobic Plate Count (aerobic bacteria per ml)		
	Sample 1	Sample 2	Sample 3
S. Pellegrino Mineral	420	30	540
Uliveto Natural Mineral	>2000	>2000	>2000
Valle de Cavalos	560	1200	>2000
Vimeiro Mineral	870	>2000	>2000
Vittel Mineral	250	1400	1300
White Mountain Spring	<10	<10	<10

(a) Total coliform and faecal coliform counts were 0 for all brands of bottled water.

Table 4 Removal of Trihalomethanes, TDS, TOC, Aluminum, Lead and Silver by Point-of-Use Devices.

Sample No.	Name of Device	Chloroform			Bromodichloromethane		
		T (ug/L)	D (ug/L)	RE (%)	T (ug/L)	D (ug/L)	RE (%)
15	Amway	5.0	<1.0	>80	5.8	<0.2	>97
12	Aqua Sana	4.9	1.9	61	5.7	3.1	46
18	Boiled Water	6.7	<1.0	>85	5.8	<0.2	>97
8	Boiled Water	3.4	<1.0	>71	4.4	<0.2	>95
20	Brita	5.8	<1.0	>83	6.2	1.6	74
1	Brita	4.0	<1.0	>75	5.2	0.2	96
3	Brita	6.9	2.1	70	6.6	2.2	67
19	Brita	5.0	<1.0	>80	5.8	1.3	78
26	CCW Systems	4.8	<1.0	>79	5.7	<0.2	>96
21	Clear'N Fresh & Sterasyl	12.9	1.0	92	9.5	1.3	86
23	Dol Fyn	3.1	<1.0	>68	4.3	<0.2	>95
13	Hur[illegible] Town & [illegible]ry	3.6	<1.0	>72	4.9	1.0	80
6	[illegible]ey Town & Country	5.0	<1.0	>80	5.7	0.7	88
4	L'Eau Pure TFC	4.2	<1.0	>76	5.3	<0.2	>96
17	Multipure	4.4	<1.0	>77	5.3	<0.2	>96
5	Nature's Spring	5.0	5.3	0	5.8	1.3	78
7	Neolife Water Dome	4.9	<1.0	>80	5.8	<0.2	>97
9	Neolife Water Dome	5.5	6.1	0	5.7	6.0	0
27	Neolife Water Dome	5.0	<1.0	>80	5.6	<0.2	>96
10	Neolife Water Dome	5.2	5.8	0	5.4	5.8	0
11	Nimbus Mini II	4.3	<1.0	>77	5.3	<0.2	>96
22	Nimbus Mini II	3.5	3.4	6	4.1	3.0	27
25	Nimbus Mini III	3.8	<1.0	>74	4.2	<0.2	>95
24	Nimbus N3A	4.0	<1.0	>75	5.4	<0.2	>96
2	NSA Bacterio-static	3.8	<1.0	>74	5.3	<0.2	>96
16	Vitalizer Mark	3.6	<1.0	>72	4.5	<0.2	>96
14	Watermill	3.4	<1.0	>70	4.2	0.3	93

T - Tap water sample
D - Water from treatment device.
RE - Chemical removal efficiency by the home water treatment device expressed as percent removal of chemical from tap water.

Table 4 Removal of Trihalomethanes, TDS, TOC, Aluminium, Lead and Silver by Point-of-Use Devices. (continued)

Sample No.	Name of Device	Dibromochloromethane			Bromoform			Total THMs		
		T (ug/L)	D (ug/L)	RE (%)	T (ug/L)	D (ug/L)	RE (%)	T (ug/L)	D (ug/L)	RE (%)
15	Amway	3.6	<0.2	>95	0.5	<0.3	>40	15.0	<0.2	>98
12	Aqua Sana	4.7	1.2	74	0.5	<0.3	>40	15.8	6.2	61
18	Boiled Water	4.1	<0.2	>95	0.5	<0.3	>40	17.1	<0.2	>98
8	Boiled Water	2.2	<0.2	>91	0.3	<0.3	NA	10.3	<0.2	>98
20	Brita	3.8	1.2	68	0.5	<0.3	>40	16.3	2.8	83
1	Brita	3.1	0.2	94	0.5	<0.3	>40	12.8	0.4	97
3	Brita	4.1	1.2	71	0.6	<0.3	>50	18.2	5.5	70
19	Brita	3.5	0.7	80	0.5	<0.3	>40	14.7	2.0	86
26	CCW Systems	3.5	<0.2	>94	0.5	<0.3	>40	14.4	<0.2	>98
21	Clear'N Fresh & Sterasyl	4.7	0.6	87	0.3	<0.3	NA	27.4	2.9	89
23	Dol Fyn	2.7	<0.2	>93	0.3	<0.3	NA	10.4	<0.2	>98
13	Hurley Town & Country	2.8	0.3	89	0.5	<0.3	>40	11.8	1.3	89
6	Hurley Town & Country	3.8	0.2	95	0.5	<0.3	>40	15.0	0.9	94
4	L'Eau Pure TFC	3.3	<0.2	>94	0.5	<0.3	>40	13.3	<0.2	>98
17	Multipure	3.1	<0.2	>94	0.5	<0.3	>40	13.2	<0.2	>98
5	Nature's Spring	3.3	<0.2	>94	0.5	<0.3	>40	14.5	6.5	55
7	Neolife Water Dome	3.5	<0.2	>94	0.5	<0.3	>40	14.7	<0.2	>99
9	Neolife Water Dome	2.5	3.0	0	0.5	0.5	0	14.2	15.6	0
27	Neolife Water Dome	3.0	<0.2	>93	0.5	<0.3	>40	14.1	<0.2	>98
10	Neolife Water Dome	2.5	2.6	0	0.5	0.5	0	13.5	14.7	0
11	Nimbus Mini II	3.2	<0.2	>94	0.5	<0.3	>40	13.3	<0.2	>98
22	Nimbus Mini II	1.6	2.0	0	<0.3	<0.3	NA	9.2	8.4	9
25	Nimbus Mini III	2.4	<0.2	>92	<0.3	<0.3	NA	10.3	<0.2	>98
24	Nimbus N3A	3.7	<0.2	>95	0.5	<0.3	>40	13.6	<0.2	>98
2	NSA Bacterio-static	3.8	<0.2	>95	0.5	<0.3	>40	13.4	<0.2	>98
16	Vitalizer Mark	1.3	<0.2	>85	0.3	<0.3	>0	9.7	<0.2	>98
14	Watermill	2.1	<0.2	>90	0.5	<0.3	>40	10.1	0.3	97

T - Tap water sample
D - Water from treatment device.
RE - Chemical removal efficiency by the home water treatment device expressed as percent removal of chemical from tap water.

Table 4 Removal of Trihalomethanes, TDS, TOC, Aluminum, Lead and Silver by Point-of-Use Devices. (continued)

Sample No.	Name of Device	TDS			TOC		
		T (mg/L)	D (mg/L)	RE (%)	T (mg/L)	D (mg/L)	RE (%)
15	Amway	230	190	17	2.0	0.5	75
12	Aqua Sana	210	220	0	2.0	4.5	0
8	Boiled Water	210	250	0	2.5	3.0	0
18	Boiled Water	190	180	5	1.5	2.0	0
1	Brita	30	170	0	1.5	3.0	0
3	Brita	130	120	8	2.0	3.5	0
19	Brita	100	90	10	2.0	1.5	25
20	Brita	200	140	30	2.0	2.5	0
26	CCW Systems	200	180	10	2.0	<0.5	>75
21	Clear'N Fresh with Sterasyl	190	170	11	3.0	1.0	67
23	Dol Fyn	190	20	89	2.0	<0.5	>75
6	Hurley Town & Country	200	210	0	2.0	<0.5	>75
13	Hurley Town & Country	190	180	5	2.0	1.0	50
4	L'Eau Pure TFC	190	20	89	2.0	<0.5	>75
17	Multipure	200	220	0	1.5	<0.5	>67
5	Nature's Spring	200	100	50	2.0	<0.5	>75
7	Neolife Water Dome	190	190	0	2.0	<0.5	>75
9	Neolife Water Dome	180	180	0	2.0	2.0	0
10	Neolife Water Dome	100	180	0	3.0	2.0	33
27	Neolife Water Dome	180	190	0	2.0	<0.5	>75
11	Nimbus Mini II	190	20	89	1.5	<0.5	>67
22	Nimbus Mini II	120	160	0	2.0	11.5	0
25	Nimbus Mini III	180	50	72	2.0	<0.5	>75
24	Nimbus N3A	60	10	83	2.0	<0.5	>75
2	NSA Bacteriostatic	140	180	0	2.0	<0.5	>75
16	Vitalizer Mark IX	200	20	90	2.0	1.5	25
14	Watermill	200	180	10	2.0	0.5	75

T - Tap water sample.
D - Water from treatment device.
RE - Chemical removal efficiency by the home water treatment device expressed as percent removal of chemical from tap water.
IN - Concentration of the chemical in the water from the treatment device.
NA - Not applicable.

Table 4 Removal of Trihalomethanes, TDS, TOC, Aluminum, Lead and Silver by Point-of-Use Devices. (continued)

Sample No.	Name of Device	Aluminum			Lead			Silver		
		T (ug/L)	D (ug/L)	RE (%)	T ug/L)	D ug/L)	RE (%)	T ug/L)	D ug/L)	RE (%)
15	Amway	200	100	50	24	<1	>96	<10	<10	NA
12	Aqua Sana	200	160	20	1	2	NA	<10	<10	NA
8	Boiled Water	180	260	0	50	39	22	<10	<10	NA
18	Boiled Water	140	140	0	8	3	63	<10	<10	NA
1	Brita	160	120	25	2	2	NA	<10	<10	NA
3	Brita	180	60	67	13	1	92	<10	60	IN
19	Brita	160	120	25	6	1	83	<10	20	IN
20	Brita	180	120	33	10	2	80	<10	40	IN
26	CCW Systems	200	120	40	2	1	NA	<10	<10	NA
21	Clear'N Fresh with Sterasyl	160	180	0	1	<1	NA	<10	<10	NA
23	Dol Fyn	220	<20	>91	13	9	31	<10	<10	NA
6	Hurley Town & Country	220	140	36	12	1	92	<10	<10	NA
13	Hurley Town & Country	200	120	40	14	2	86	<10	<10	NA
4	L'Eau Pure TFC	200	<20	>90	3	<1	>67	<10	<10	NA
17	Multipure	160	140	13	47	2	96	<10	<10	NA
5	Nature's Spring	240	20	92	8	<1	>88	<10	<10	NA
7	Neolife Water Dome	180	140	22	7	<1	>86	<10	<10	NA
9	Neolife Water Dome	140	160	0	198	100	49	<10	<10	NA
10	Neolife Water Dome	220	180	18	26	27	0	<10	<10	NA
27	Neolife Water Dome	160	120	25	1	1	NA	<10	<10	NA
11	Nimbus Mini II	180	<20	>89	2	1	NA	<10	<10	NA
22	Nimbus Mini II	260	60	77	11	<1	>91	<10	<10	NA
25	Nimbus Mini III	220	<20	>91	7	1	86	<10	<10	NA
24	Nimbus N3A	240	<20	>92	1	2	NA	<10	<10	NA
2	NSA Bacteriostatic	180	140	22	21	2	90	<10	<10	NA
16	Vitalizer Mark IX	160	<20	>88	13	<1	>92	<10	<10	NA
14	Watermill	240	40	83	9	<1	>89	<10	<10	NA

T - Tap water sample.
D - Water from treatment device.
RE - Chemical removal efficiency by the home water treatment device expressed as percent removal of chemical from tap water.
IN - Concentration of the chemical in the water from the treatment device.
NA - Not applicable.

manufacturers of these devices do not make claims for aluminum reduction. Most devices claiming a capacity to reduce lead did reduce it.

Bacteria

The Ontario Drinking Water Objectives stipulate that no faecal coliform bacteria should be present in treated tap water. The field study indicated that for two of the 25 devices tested, faecal coliform counts were in excess of 80 per 100 ml, in the water generated by the device. One of these two households also had elevated faecal coliform levels in the tap water contrary to the Ontario guideline. Table 5 presents the results of these analyses. The presence of faecal coliforms in drinking water can indicate a potential serious risk to health.

The Ontario Drinking Water Objectives stipulate a maximum level for total coliforms of five bacteria per 100 ml. (In the United States, the maximum acceptable level for total coliforms is one per 100 ml.) The field study of treatment devices in 25 homes demonstrated that 24 percent of the first-draw and 16 percent of the flushed water samples from the treatment devices contained higher levels of total coliforms than specified by the Ontario guidelines.

The Ontario Drinking Water Objectives stipulate a maximum desirable concentration of 500 bacteria per ml (APC). In the field study, 88 percent of the first-draw samples collected from devices in 25 homes exceeded the Ontario APC guideline for aerobic bacteria, and 68 percent of the flushed samples did as well. This compares with 24 percent (first-draw) and zero (flushed) of non-treated tap water samples collected in the homes that exceed the Ontario guideline.

These results suggest that the bacteriological quality of water additionally treated in the home with a water treatment device was inferior to that of Toronto tap water.

The field study questionnaire revealed that although 70 percent of the 25 householders that participated in the field study still had maintenance instructions for their device, most users had poor recollection of the date of the last filter change or maintenance procedure. All users reported that maintenance instructions were not attached to the device itself for easy reference. This is significant because the results of removal-efficiency tests indicate that proper maintenance is essential to prevent "break through" of contaminants through a poorly maintained or over-age device.

Table 5 Bacteriological Results for Home Water Treatment Systems.

Sample No.	Name of Device	Faecal Coliforms (/100 ml)				Total Coliforms (/100 ml)			
		Tap		Device		Tap		Device	
		First Draw (a)	Flushed (b)	First Draw (a)	Flushed (b)	First Draw (a)	Flushed (b)	First Draw (a)	Flush (b)
15	Amway	0	0	0	0	0	0	2	0
12	Aqua Sana	0	0	0	0	0	0	0	0
3	Brita	0	0	0	0	0	0	0	0
19	Brita	0	0	0	0	0	0	0	0
20	Brita	0	0	0	0	2	0	0	0
1	Brita	0	0	0	0	0	0	49	1
26	CCW Systems	0	0	>80	0	15	0	>80	3
21	Clear'N Fresh w/Sterasyl	0	0	0	0	0	0	0	0
23	Dol Fyn	0	0	1	0	0	0	1	0
13	Hurley Town & Country	0	0	0	0	0	0	0	0
6	Hurley Town & Country	0	0	0	0	0	2	>80	>80
4	L'Eau Pure TFC	0	0	0	0	0	0	0	0
17	Multipure	0	0	0	0	1	2	0	0
5	Nature's Spring	0	0	0	0	0	0	0	4
27	Neolife Water Dome	0	0	0	0	0	0	0	0
10	Neolife Water Dome	0	0	0	0	0	0	0	0
9	Neolife Water Dome	0	0	0	0	0	0	0	0
7	Neolife Water Dome	0	0	0	0	0	19	1	0
11	Nimbus Mini II	0	0	0	0	0	0	>80	>80
22	Nimbus Mini II	0	0	0	0	0	0	22	26
25	Nimbus Mini III	10	1	>80	>80	48	12	>80	>80
24	Nimbus N3A	0	0	0	0	0	0	0	0
2	NSA Bacteriostatic	0	0	0	0	0	1	0	0
16	Vitalizer Mark IX	0	0	0	0	0	0	5	1
14	Watermill	0	0	0	0	0	0	5	1
8	Boiled Water	0	0	0	0	0	4	0	0
18	Boiled Water	0	0	0	0	1	1	0	0

(a) First 100 ml sample collected from disinfected faucet.
(b) Sample collected after approximately 1 litre of water had passed through the faucet.

Table 5 Bacteriological Results for Home Water Treatment Systems. (continued)

Sample No.	Name of Device	Aerobic Plate Count (per 1 ml)				Background Bacteria (per 100 ml)			
		Tap		Device		Tap		Device	
		First Draw (a)	Flushed (b)	First Draw (a)	Flushed (b)	First Draw (a)	Flushed (b)	First Draw (a)	Flush (b)
15	Amway	10	50	>2000	>2000	0	0	>200	0
12	Aqua Sana	240	100	>2000	50	0	0	0	0
3	Brita	<10	<10	<10	10	0	1	0	0
19	Brita	<10	<10	740	30	0	0	0	0
20	Brita	<10	<10	60	<10	3	0	0	0
1	Brita	160	10	>2000	>2000	0	0	>200	>200
26	CCW Systems	20	40	590	140	70	0	150	3
21	Clear'N Fresh w/Sterasyl	80	60	>2000	1700	49	21	0	0
23	Dol Fyn	<10	<10	>2000	>2000	0	0	2	0
13	Hurley Town & Country	170	40	>2000	>2000	17	1	0	0
6	Hurley Town & Country	560	10	>2000	>2000	0	3	>200	>200
4	L'Eau Pure TFC	720	20	>2000	>2000	>200	0	0	0
17	Multipure	650	10	1600	40	0	0	0	0
5	Nature's Spring	10	10	1400	>2000	0	0	14	>200
27	Neolife Water Dome	10	<10	>2000	150	0	0	1	0
10	Neolife Water Dome	90	10	>2000	660	0	0	>200	12
9	Neolife Water Dome	<10	<10	430	100	0	0	1	0
7	Neolife Water Dome	70	<10	>2000	1100	38	190	160	0
11	Nimbus Mini II	600	30	>2000	1100	0	0	>200	>200
22	Nimbus Mini II	600	0	>2000	>2000	2	0	>200	>200
25	Nimbus Mini III	100	120	>2000	>2000	38	40	>200	>200
24	Nimbus N3A	<10	<10	990	560	0	0	0	0
2	NSA Bacteriostatic	460	<10	>2000	>2000	0	0	18	17
16	Vitalizer Mark IX	30	<10	>2000	>2000	0	0	>200	>200
14	Watermill	530	<10	>2000	>2000	2	0	>200	130
8	Boiled Water	20	30	50	120	0	4	14	>200
18	Boiled Water	60	30	20	10	1	2	0	0

(a) First 100 ml sample collected from disinfected faucet.
(b) Sample collected after approximately 1 litre of water had passed through the faucet.

9.0 COMPARISON OF TAP WATER, BOTTLED WATER AND DEVICE-TREATED WATER

Reference to Tables 1 and 2 shows that different detection limits were used for the low detection limit study (tap water and device-treated water) than were used for the analysis of bottled water. To allow a fair comparison, only values measured above the higher detection limits were considered in the following analysis.

The "Priority" Chemicals

A conventional risk assessment procedure applied to Toronto tap water allowed the identification of chemical constituents that may be of public health concern. In particular, six chemicals were present in concentrations that are already at or above "acceptable" levels. For the purpose of this analysis, an "acceptable" concentration for known or presumed carcinogens was defined as one which, ingested over a 70 year lifetime in two litres of water per day, would result in less than a one in a million chance of cancer occurrence. For comparison, the current average Canadian lifetime cancer risk, excluding skin cancer, is between one-in-four and one-in-three. In addition, it has been estimated that smoking 1.4 cigarettes annually increases the annual chance of lung cancer by one in a million. For non-carcinogens such as aluminum and barium "acceptable" concentration was defined as one which if ingested over a 70 year lifetime would result in no observable adverse health effect.

The six chemicals identified in the risk assessment as having little or no "relative margin of safety" were lead, aluminum, bis(2-ethylhexylphthalate), chloroform, alpha-hexachlorocyclohexane and tetrachloroethylene. Of these, only lead and chloroform currently have health-based guidelines in Canada. The chloroform guideline is actually an "umbrella" value which includes all the other trihalomethanes.

A further seven chemicals were identified as having somewhat reduced "relative margins of safety" (within a factor of 10 of the "acceptable" level). While these are not of immediate health concern, it may be advisable over the longer term to consider reducing their concentrations and thus the risk of exposure to them. These were chromium, trichloroethylene, barium, lindane, cyanide (total), bromodichloromethane and dibromochloromethane.

This body of 13 chemicals thus provided a "priority" list against which to evaluate the various sources of drinking water.

The results of this study suggest that, under good operating and maintenance conditions, reverse osmosis/activated carbon treated water has the potential to contain the lowest levels of the priority contaminants. Activated carbon treated water has the next lowest level of contaminants, followed by bottled water. Tap

water contained the highest levels, but it must be noted that several of the contaminants are added intentionally as part of the treatment process, such as aluminum and the trihalomethanes.

Tap water contained the highest levels of trihalomethanes, but bottled water showed the highest levels of other chlorinated compounds (for example, 1,2-dichlorobenzene, 1,4-dichlorobenzene and 1,2,3,4-tetrachlorobenzene), of base neutral compounds (for example, naphthalene and benzothiozole), and of volatile organics (for example, carbon tetrachloride and toluene). Many of these compounds are known to cause adverse reproductive effects in animal studies.

Phthalates were present in tap water, carbon-treated and reverse-osmosis treated water. In bottled water, phthalate levels varied greatly by brand, but on average were lower than for other alternatives. Phthalates are used in the manufacture of many plastics. These chemicals may leach from plastic into water stored in certain plastic containers or passing through plastic pipes. Phthalates are of concern because of evidence that they cause cancer and reproductive effects in animal studies. This study was not able to conclude whether the phthalates measured in the drinking water originated in the source of water or in the means of distribution.

Tap water had the highest levels of aluminum compared to the other sources. Levels of other trace metals were also somewhat higher in tap water than in device-treated water. Some brands of bottled water showed the highest levels of trace metals over-all. However, it must be noted that there was considerable variation among brands with respect to metal content, with some brands containing lower levels than tap water.

Bacteria

The results of this study suggest that tap water has the best bacteriological quality, followed by bottled water. Water treated with a home treatment device had the poorest bacteriological quality, demonstrating frequent and significant exceedance of Ontario guidelines for faecal coliforms, total coliforms and aerobic plate counts.

Potential Health Effects

Although chemical exposures are lowest with properly maintained home treatment devices compared to bottled water and tap water, the opposite appears to be true with respect to exposures to bacteriological contamination. Device-treated water tended to have the poorest microbiological quality of the alternatives tested and consequently would appear to present a greater exposure with respect to bacteriological parameters.

This study cannot make conclusive statements as to the relative quality of the water made available through the many brands of bottled water and treatment devices on the market because budget constraints prohibited the comprehensive testing of all brands. This study does, however, provide considerable information on the merits and disadvantages of the major sources of Toronto water, whether tap water, bottled water or device-treated water. The concerned consumer must weigh the potential and perceived health risks inherent in each source against the potential benefits. This includes taste and aesthetic values. In doing so, it is important to place the theoretical risks of consuming drinking water from any source in the context of risks posed by breathing air or eating food, both major routes by which chemicals enter the human body. For the purpose of this study, we assumed that drinking water accounted for 20 percent of an individual's daily exposure.

On the basis of the study results, the Department of Public Health confirms its longstanding position that residents of the City of Toronto can continue to drink tap water with reasonable assurance that it is not likely to cause harm or injury. The Department does not promote the use of alternatives to tap water because of their inconsistent bacteriological quality, their variable chemical quality, and the lack of applicable standards to guarantee the quality of product to the consumer. In addition, they are costly relative to tap water and thus may be inaccessible to a large sector of the population.

Nevertheless, it is likely that the quality of Toronto tap water can be further improved. Government officials and the public should work closely together in making decisions about "acceptable" levels of exposure or risk, and hence acceptable expenditures on additional treatment technologies. A few candidate technologies and management practices are presented for discussion in the next section.

10.0 CANDIDATE TECHNOLOGIES FOR IMPROVING THE QUALITY OF TORONTO TAP WATER

More advanced and costly municipal water treatment technologies are in use in some U.S. and European communities. These sophisticated technologies could in principle reduce the levels of most contaminants including the priority chemicals identified in Toronto tap water.

Furthermore, the cost per person for improvements to municipal water treatment is less than if every resident were to pay individually for an alternative such as a home treatment device or bottled water. In Cincinnati, advanced treatment such as Granular Activated Carbon (GAC) or Biological Activated Carbon (BAC) is estimated to cost about $40 per person per year over a ten year

period. In contrast, city-wide use of a home water treatment device is estimated to cost about $110 for a reverse osmosis unit and about $30 for an activated carbon unit per person per year over a ten year period. The annual cost of bottled water per person, assuming two litres are consumed each day, ranges from $220 to $380, depending on whether water is delivered in bulk to the home or purchased in smaller containers at a store.

Feasibility studies will be helpful in determining which technologies are best to apply and whether the associated costs are worth the anticipated reduction in chemical exposure. The Metropolitan Toronto Works Department is currently investigating some of these approaches.

Biological Activated Carbon (BAC)

BAC is an important advanced water treatment technology to consider for minimizing trihalomethane levels and for eliminating many of the trace toxic organic compounds found in tap water. It is used in Europe and combines the use of ozone (as an oxidant and disinfectant) with Granular Activated Carbon (GAC).

The introduction of GAC or BAC to water treatment plants in Toronto represents the most expensive centralized water treatment improvement available, and would generate the most comprehensive reduction of a wide range of trace toxic contaminants. The introduction of GAC or BAC technologies could mean that existing water bills are more than doubled.

Aluminum Reduction Through Process Change

Aluminum occurs in Toronto tap water as a result of the addition of aluminum compounds during treatment to improve the clarity of the treated water. The treatment process typically results in a three to five fold increase in aluminum levels in treated water compared with raw water from Lake Ontario.

Prior to 1984, the Metro Works Department applied aluminum compounds during water treatment on an "as needed basis". Between 1979 and 1983, mean aluminum levels in treated water were approximately 80 ppb. In 1984, "continuous coagulation/flocculation" was introduced to the treatment process, resulting in average aluminum residuals in treated water of about 160 ppb between 1984 and 1987.

Given the increasing health concern about aluminum in drinking water, it may be advisable to substitute less toxic, coagulant compounds for aluminum, or to return to the practice of adding aluminum compounds on an "as needed" basis.

Reduction of Lead Through Corrosion Control and Tap Flushing

Lead levels are low in water leaving Toronto's treatment plants, but those levels increase through the distribution system and particularly in the home, where water may stand in lead or lead-soldered plumbing for several hours.

The reduction of lead exposures through tap water requires both immediate and long-term actions. In the short-term, citizens should flush standing water prior to drinking. However, as a long-term strategy, a water flushing program is wasteful and inconvenient.

Corrosion control of water at the treatment plant can be achieved through changes to the acidity of the water before it leaves the plant. Reduced corrosiveness would likely provide more comprehensive protection against the leaching of lead from the distribution system.

Finally, prohibit the sale of lead-based solder and lead pipes is the best long-term solution. The reduction of the Canadian and Ontario guidelines for lead in water from 50 ppb to 10 ppb in keeping with the United States is a useful strategy because this action will stimulate corrosion control and public awareness programs. Similarly, the removal of all lead service connections and lead-based solder is an effective long-term solution and can be done by attrition.

Ozonation to Reduce Trihalomethane Levels

One promising method of reducing trihalomethane levels is to use ozone to disinfect water. Ozone is the most powerful of the major disinfection agents used for water, but its effect does not persist through the distribution system. A second agent such as chlorine or chloramine must therefore be added to protect the quality of water in the distribution system. Although there are some concerns regarding the toxicity of ozonation by-products, most studies suggest that ozonated water may be superior to chlorinated water.

Measures the Consumer Can Take at the Point of Consumption

Several simple measures are available to the consumer who wishes to reduce exposure risks. Flushing of taps demonstrably reduces lead concentrations, particularly when the water has been standing for several hours. Flushing also reduces the slight risk of bacteria accumulating in the tap.

In this study, boiling water for five minutes reduced trihalomethane levels in tap water by more than 98 percent, and it is likely that other compounds such as trichloroethylene, tetrachloroethylene, toluene and xylene would also be reduced.

This obviously presents a ready alternative for parents seeking an alternate way of reducing an already low childhood exposure.

Metro Works Department Initiatives to Improve Municipally Treated Drinking Water Quality

The Metropolitan Toronto Department of Works is currently planning a major expansion of its R. L. Clark Filtration Plant, to be completed from 1992 to 1995 at a projected cost of $197 million. As part of that expansion, the Department is investigating some of the technologies discussed above, among others. A number of these have been tested in pilot studies and have shown promising results. The Department of Public Health supports these initiatives. In carrying out this work, Metro Works has selected the most stringent available guidelines for their treatment criteria.

Current proposed changes include:

(a) preoxidation using ozone to assist in flocculation and improve taste and odour;

(b) taking measures to reduce aluminum concentrations in the finished water;

(c) dechlorination prior to ammoniation to reduce excess chlorine and THM levels;

(d) lessen the corrosivity of the water prior to its leaving the plant to reduce its ability to dissolve lead from plumbing.

An underground reservoir has been designed as part of the expansion. Although GAC and BAC will not be implemented at this stage, the reservoir is designed to accommodate future expansion for GAC equipment. The pilot studies have shown that it is possible to reduce THMs to levels of 3-6 ug/l without the use of GAC. At present, an advanced oxidation process using hydrogen peroxide is the preferred method. Changes to other plants will be considered after the Clark expansion has been completed.

In addition to these initiatives, Metro Works has retained a consultant to develop components of their Water Supply Master Plan for the period 1990 to 2011. This Plan will include a comprehensive study of present and future water quality objectives for Metropolitan Toronto, including detailed forecasting of future demand. Taken together, these proposals are in keeping with the recommendations of this report and promise significantly improved tap water quality by 1992.

11.0 REDUCING EXPOSURE RISKS FOR ALTERNATIVE SOURCES OF DRINKING WATER

Bottled Water

Under existing law, suppliers of bottled water are not required to undertake comprehensive chemical testing of their product, nor to disclose to the public the results of such testing if they have them. Health and Welfare Canada does compliance testing of bottled water for bacteriological parameters under the Food and Drugs Act, but not for trace toxic chemicals. Furthermore, Health and Welfare Canada currently does not release bacteriological test results by brand to the public.

Although the Ontario Bottled Water Association encourages its members to undertake chemical testing of their product in conformance with the Canadian Drinking Water Guidelines, and encourages the distribution of test results to the public upon request, such action is strictly voluntary.

The potential consumer of bottled water, therefore, has no evidence that a particular bottled water product meets drinking water guidelines or is superior to tap water. The introduction of regulatory measures to require adequate chemical and bacteriological testing and public disclosure of test results for bottled water would likely lead to improvements in the quality of bottled water on the market, particularly with respect to bacteriological quality.

Home Treatment Devices

The field study of water treatment devices in Toronto clearly revealed that removal efficiencies depend on the age and maintenance of the device. However, it also showed that most residents were unsure of the life expectancy of their device and its required maintenance schedule.

The potential health risks associated with home water treatment devices can be reduced by careful attention on the part of consumers to the manufacturer's recommendations for maintenance and replacement. Attention to filter changes is essential.

In the longer term, regulations should be developed requiring manufacturers to place maintenance instructions in a visible area on each device, requiring vendors to administer a maintenance program with each consumer, and establishing a certification process for all water treatment devices permitted for sale in Canada.

12.0 SUMMARY AND CONCLUSIONS

This study provides evidence of the presence of organic and inorganic trace contaminants in municipally treated drinking water, water treated with a point-of-use device, and bottled waters. Bacteriological contamination was also noted frequently in device-treated water and bottled waters.

Many of the chemicals measured in this study are the same chemicals that scientists have detected in the water, sediment, fish, birds and other biota of the Great Lakes Ecosystem, particularly in Lake Ontario and the Niagara River. The presence of these chemicals in drinking water emphasizes the need for concerted action on both sides of the Canada-U.S. border to virtually eliminate the discharge of persistent toxic substances into the Great Lakes basin.

Drinking water is only one source through which humans are exposed to contaminants. Food and air are also major exposure routes. The risks inherent in life-long ingestion of tap water, device-treated water, and bottled water are difficult to estimate given current uncertainty in the scientific literature and divergence of opinion as to how best to estimate risk.

Nevertheless, an assessment of the relative quality of the three major sources resulted in the following conclusions:

1. In the view of the Department of Public Health, tap water is currently the best choice for drinking water in terms of health considerations. The Department thus confirms its longstanding position that residents of the City of Toronto can continue to drink tap water with reasonable assurance that it is not likely to cause harm or injury.

2. The Department does not promote the use of alternatives because of their currently inferior bacteriological quality, their variable chemical quality, and the lack of applicable standards to guarantee the quality of product to the consumer. In addition, they are costly relative to tap water and thus may be inaccessible to a large sector of the population.

3. There is considerable variation in the quality of the major sources of water used by Toronto residents, and thus in the risks associated with lifetime ingestion of those sources. This problem could be corrected in large part by the introduction of legally-enforceable standards for drinking water.

This study has identified the presence of 66 substances in Toronto tap water, about 42 of which may occur on a regular basis. The results are reassuring because they quantify chemical exposure

levels, and determine through risk assessment procedures that most of these exposures are so low as to be of little, if any, health consequence.

Six contaminants measured in Toronto tap water were observed to occur at levels that are at, or above, "acceptable" concentrations as determined in the risk assessment (lead, chloroform, aluminum, alpha-hexachlorocyclohexane, bis(2-ethylhexyl)phthalate and tetrachloroethylene). A further seven chemicals are present at concentrations that, while not currently of major health significance, have a relatively low "margin of safety" remaining. These were chromium, trichloroethylene, barium, lindane, cyanide (total), bromodichloromethane and dibromochloromethane.

Prudent public health policy would suggest undertaking measures to reduce the levels of all of these contaminants in drinking water. Various technologies are available to improve the quality of Toronto tap water. The introduction of GAC or BAC to water treatment plants in Toronto would represent the most expensive centralized water treatment improvement available, and would probably provide the most comprehensive reduction of a wide range of trace toxic chemicals. The introduction of GAC or BAC technologies would likely mean that existing water bills are more than doubled.

In contrast, treatment plant and distribution system changes directed at minimizing the priority contaminants, particularly lead, aluminum and trihalomethanes (including chloroform) would appear to be less costly while offering an immediate improvement in water quality.

Government officials should work closely with the public in determining levels of "acceptable" risk, and thus "acceptable" levels of public expenditure on treatment improvements.

13.0 RECOMMENDATIONS

The following section summarizes the Medical Officer of Health's recommendations for actions leading to a reduction in chemical and bacterial exposures associated with the consumption of municipally treated water, bottled water and water treated by point-of-use devices.

RECOMMENDATION 1: IMPLEMENTATION OF VIRTUAL ELIMINATION OF PERSISTENT TOXIC SUBSTANCES INTO THE ENVIRONMENT

That the International Joint Commission and the Canadian and Ontario Ministers of the Environment be requested to expedite the implementation of the virtual elimination of persistent toxic substances into Lake Ontario specifically, and into the Great Lakes ecosystem at large.

RECOMMENDATION 2: RESEARCH AND IMPLEMENTATION OF IMPROVED WATER TREATMENT OPTIONS

That the Commissioner of the Works Department, Metropolitan Toronto, in consultation with the Ontario Minister of the Environment, be requested to expedite the implementation of improvements to the water treatment process to reduce the public's exposure to priority contaminants. In the short-term, particular attention should be placed on reducing exposures to lead, trihalomethanes and aluminum, as reduction for these parameters is likely to be most cost effective. In the longer term, attention should be directed at reducing exposures to the multitude of trace toxic contaminants present in tap water.

RECOMMENDATION 3: FURTHER INVESTIGATION OF MICROBIOLOGICAL QUALITY OF MUNICIPALLY TREATED WATER AT THE POINT OF CONSUMPTION

That the Commissioner of the Works Department, Metropolitan Toronto, further investigate the microbiological quality of municipally treated drinking water at the consumer's tap. If further investigation suggests contamination at the point of consumption, it is recommended that appropriate action be taken to identify and correct the causative factors.

RECOMMENDATION 4: REGULATORY AND ENFORCEMENT INITIATIVES

That the Canadian Minister of Health and Welfare be requested to enact a Safe Drinking Water Act for Canada, and that this Act should include, at minimum:

a) Enforceable standards for all sources of drinking water, including bottled water;

b) Mandatory periodic review of drinking water standards;

c) Adoption of drinking water criteria from other jurisdictions where they are more stringent, and consequently health protective, than those in use in Canada, such as for trihalomethanes and microbiological parameters;

d) Avenues for public participation in the development and formulation of drinking water standards;

e) Mandatory monitoring, analysis, and public disclosure of results for both municipally treated and bottled water; and

f) Notice requirements for non-compliance and exceedances.

RECOMMENDATION 5: REGULATORY IMPROVEMENTS AFFECTING WATER TREATMENT DEVICES

That the Canadian Minister of Consumer and Corporate Affairs be requested to:

a) Require placement of maintenance instructions by the manufacturer or distributor in a visible place on each water treatment device;

b) Encourage all vendors of home water treatment devices to administer a maintenance program with each customer;

c) Establish a certification process for all point-of-use devices that would incorporate approval mechanisms by reputable, independent bodies such as the National Sanitation Foundation (U.S.) or the Canadian Water Quality Association; and

d) Ensure that marketers of water treatment devices and bottled water do not mislead the public through claims in advertising.

RECOMMENDATION 6: PROHIBITION ON THE SALE OF LEAD-CONTAINING SOLDER AND LEAD PIPE

That the Federal Minister of Consumer and Corporate Affairs be requested to prohibit the sale of lead-containing solder and lead pipe in Canada.

RECOMMENDATION 7: REVIEW OF RISKS ASSOCIATED WITH ALL SOURCES OF DRINKING WATER

That the Ontario Minister of the Environment (OMOE) and the Canadian Minister of Health and Welfare be requested to review the risks involved with all sources of drinking water, and inform the public as to the results of these reviews.

RECOMMENDATION 8: "LEAD IN DRINKING WATER" PUBLIC AWARENESS PROGRAM

That the Commissioners of the Works Departments for Metro Toronto and the area municipalities, in consultation with the Medical Officers of Health of Metropolitan Toronto, be requested to institute a 'lead in drinking water' public awareness program as a short-term strategy for the amelioration of the health risk associated with lead in drinking water. This program would provide information to the public about the levels of lead in drinking water at the point of use, the risks of exposure, and how to reduce the risks through flushing. It is also recommended that the above program should inform the public of the longer-term solutions to the lead issue and what Metro Toronto is doing to implement those solutions.

CITY OF TORONTO
DEPARTMENT OF PUBLIC HEALTH

September 13, 1990

To: Board of Health

Subject: The Quality of Drinking Water in Toronto

Origin: Medical Officer of Health
(c34hlth90062:632)

RECOMMENDATION:

That the Board of Health adopt the recommendations contained in this report.

COMMENTS:

This report is the first component of a large research project undertaken by the Department of Public Health to provide information on the "typical" background exposures to trace contaminants that Torontonians face each day. I wish to draw to the attention of the Board of Health that the attached report is a summary of the larger scientific document entitled "The Quality of Drinking Water in Toronto: A Review of Tap Water, Bottled Water and Water Treated by a Point-of-Use Device".

Public concern over the quality of drinking water in Toronto has grown over the past few years to the point where surveys show that a significant portion of the Toronto population is using some kind of alternative to municipally treated tap water, and sales figures for bottled water and home treatment devices have increased dramatically. Nonetheless, it is important to recognize that other exposure pathways such as air, food and soil likely contribute more to an individual's body burden of toxic chemicals than drinking water. A study assessing exposures to toxic pollutants in Toronto air is underway, and studies are planned to assess exposures through food and soil. The collection of this information will provide an important tool in making rational, cost-effective choices as to how to best reduce risks associated with environmental exposures to potentially toxic chemicals in Toronto.

Given the current state of science, no study can conclusively answer the question of what health risks are posed by the long-term consumption of Toronto's drinking water, whether it is obtained from the municipal water supply, bottled water or water treated in the home with a device. At present, the ability to

measure extremely small quantities of chemicals far exceeds the ability of scientists to determine with certainty the type and magnitude of health impacts that result from chronic exposure to chemicals at the very low levels measured in drinking water.

A definitive answer to the question of what, if any, are the adverse health impacts of long-term consumption of drinking water must await the development of more sensitive epidemiological study techniques and their application to human populations in the future. In the interim, scientists must rely on risk assessment procedures to determine theoretical risks associated with exposure to a single chemical at a time. The risks are theoretical because they are usually extrapolated from animal studies to a dose range hundreds of times lower than the dose that results in measurable health damage in the test animal.

Unlike most other studies to date which fail to detect many chemicals in tap water, the current study provides evidence of the daily presence of dozens of chemicals in treated drinking water drawn from Lake Ontario. As expected, many of the chemicals measured in this study are the same chemicals that scientists have detected in the lake water, sediments, fish, birds and other biota of the Great Lakes ecosystem, particularly in Lake Ontario and the Niagara River. The presence of these chemicals in drinking water emphasizes the need for concerted international action on both sides of the Canada-United States border to implement the virtual elimination of discharge of persistent toxic substances into the Great Lakes basin, as called for by the International Joint Commission and as agreed to under the terms of the Great Lakes Water Quality Agreement as revised in 1987.

Many of these same persistent toxic chemicals find their way into and bioaccumulate up the food chain. Most of these chemicals have limited solubility in water but tend to concentrate in fatty components such as occur in fish, meat and dairy products. This is the major reason why food is generally a much greater source of human exposure to persistent toxic chemicals than is drinking water.

This study has measured the presence of 66 substances in Toronto tap water, 42 of which occur on a frequent basis. The results are reassuring because they quantify chemical exposure levels, and determine through risk assessment procedures that most of these exposures are so low as to be of little, if any, health consequence. The study by identifying six "priority chemicals" separated contaminants measured in Toronto tap water into two categories, those with negligible health risk and those for which prudent health policy would suggest undertaking measures to reduce their current levels in drinking water.

Of the six priority chemicals flagged in this study, the levels of lead, chloroform, aluminum and alpha-hexachlorocyclohexane were higher in tap water than in bottled water and device-treated water. The levels of the other two priority chemicals, bis(2-ethylhexyl)phthalate and tetrachloroethylene, were similar for tap, bottled and device-treated water. It is likely that reasonably cost-effective treatment improvements undertaken at Metro Toronto's water treatment plants could reduce aluminum, chloroform and alpha-hexachlorocyclohexane in the near future to such levels that Toronto tap water would be superior to that of its current alternatives. In addition, measures taken at the drinking water treatment plant can reduce the public's exposure to lead from lead leaching in the water distribution system.

Before any improvements in municipal water treatment are implemented in Toronto, it is critical that appropriate feasibility studies be undertaken to determine which technologies are best to apply and whether the associated costs are worth the anticipated reduction in chemical exposure. Furthermore, it must be recognized that no amount of advanced water treatment will ever remove all contaminants from treated tap water. However, it may be possible to reduce the existing levels of routine exposure.

Although this study confirms the Department of Public Health's long-standing position that residents of Toronto can drink tap water with reasonable assurance that it is not likely to cause harm or injury, it should be of great concern to all who rely upon the Great Lakes for drinking water that effective measures to eliminate known sources of contamination have yet to be fully implemented. This study clearly identifies measures to be undertaken from the standpoint of prudent public health policy to reduce exposures to priority chemicals. The Department of Public Health does not promote the use of alternatives to municipally treated tap water.

Both the public and government officials must contribute to the decision-making process to determine what level of public expenditure on improved municipal water treatment is reasonable in order to achieve a purity in tap water that is acceptable to the public. Drinking water is one source of chemical exposure. Other routes of exposure include food and air, each of which may also require considerable public expenditures to reduce existing chemical exposures.

BB/ht

P.R.W. Kendall, MBBS, MSc, FRCPC
Medical Officer of Health